Demonstrating the Operational Value of Atmospheric Infrared Sounder (AIRS) Profiles in the Pre-convective Environment

Danielle Kozlowski[1], Bradley Zavodsky[2], Geoffrey Stano[2] , Gary Jedlovec[2]
[1]SEAS Department, University of Missouri, Columbia, Missouri
[2]NASA Short-term Prediction Research and Transition (SPoRT) Center, Huntsville, Alabama

Introduction/Motivation

- SPoRT is a project to transition unique NASA observations and research capabilities to the operational weather community to improve short-term regional forecasts
- Thunderstorm forecasts are challenging in regions where there are little or no traditional upper air observations (e.g. the Gulf of Mexico)
  - Structure of upper air is important to these forecasts
  - Key variables to thunderstorms forecasts were identified as Convective Available Potential Energy (CAPE) and vertical soundings by forecasters at the Huntsville Weather Forecast Office (WFO)
- Aboard NASA's Aqua satellite, the Atmospheric Infrared Sounder (AIRS), which provides temperature and moisture profiles of the atmosphere, can add additional information in data void regions
- This project is designed to determine the impact of AIRS profiles on thunderstorm situational awareness

Methodology

- AIRS is a cross-track scanning infrared spectrometer/radiometer with 2378 spectral channels between 3.7 and 15.4 μm (Aumann et. al 2003)
  - Profiles obtained in clear and partly cloudy scenes
  - Analyses of AIRS data removes uncharacteristic features from individual profiles to give forecasters a higher confidence in the data
- WRF-Var Analysis used to blend AIRS profiles into model background
  - A 9-h Advanced Research Weather Research and Forecasting (WRF-ARW) model forecast is used as the first-guess field
  - Each WRF forecast is initialized at 0000 UTC and 1200 UTC using a "cold start" from the 40-km North American Model (NAM) analysis
  - Analyses valid at 0900 UTC and 2100 UTC
- Used quality indicator (QI), P_{best}
  - Approximate definition of cloud level
  - Selects the most favorable data from each profile for data assimilation
- Compare control analysis (WRF forecast representing model an operational forecast; CNTL) to an AIRS analysis
  - Compare CNTL and AIRS analysis to Rapid Update Cycle (RUC) analysis used by operational forecasters
  - Does AIRS alter the CNTL analysis to better resemble the RUC analysis?

17 June 2010: Southeast U.S. Convection

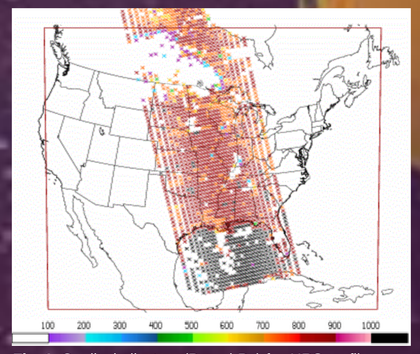

Fig. 1. Quality indicators (P_{best} ; hPa) for AIRS profiles assimilated at 2100 UTC on 17 June 2010. Black points represent the highest quality data, while white regions indicate gaps in the data likely due to cloud cover.

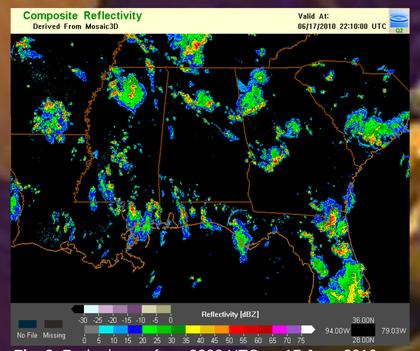

Fig. 2. Radar image from 2200 UTC on 17 June 2010 indicating widespread convection across the southeast U.S. Image from National Mosaic & Multi-Sensor QPE.

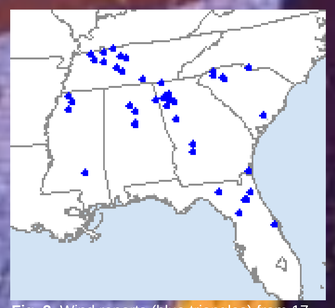

Fig. 3. Wind reports (blue triangles) from 17 June 2010. Image from Storm Prediction Center (SPC).

- Quality AIRS data are located over the southeast United States and the Gulf of Mexico (Fig. 1)
- Convection was widespread at 2200 UTC in the southeast U.S. and along the Gulf Coast (Fig. 2); multiple severe wind reports were recorded (Fig. 3)
- Overall, the RUC shows lower values of CAPE compared to the CNTL over land. It also shows higher values of CAPE over water (Figs. 4a and 4c)
- AIRS increases convective potential over both land and water (Fig. 4)
  - AIRS analysis shows large values of CAPE over central and southern MS and AL, where less widespread convection occurred
  - AIRS analysis shows larger values of CAPE over the Gulf, which is more consistent with the RUC and observed convection over the Gulf Coast (See Fig. 2)

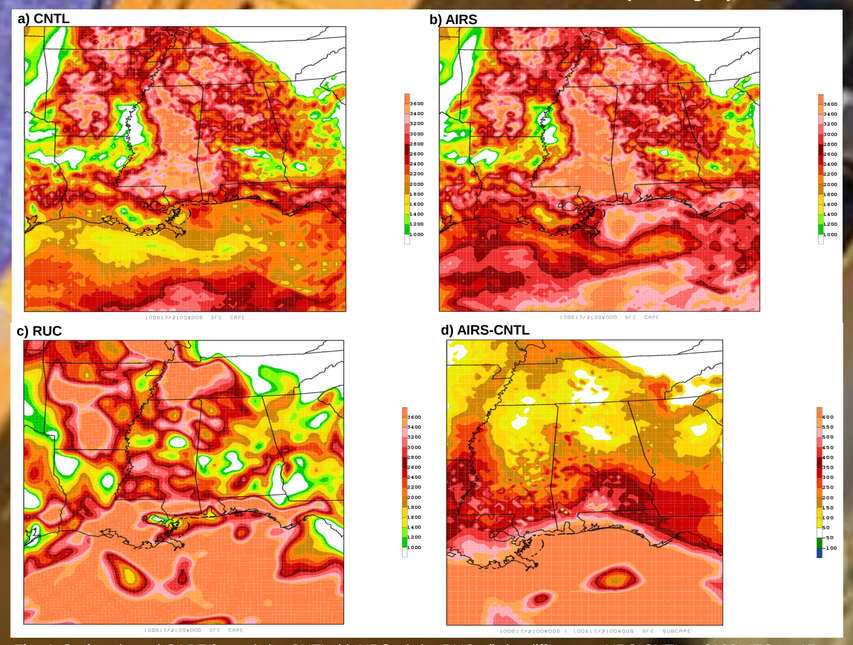

Fig. 4. Surface based CAPE from a) the CNTL, b) AIRS, c) the RUC, d) the difference; AIRS-CNTL at 2100 UTC on 17 June 2010 over the domain.

28 June 2010: Gulf Coast Convection

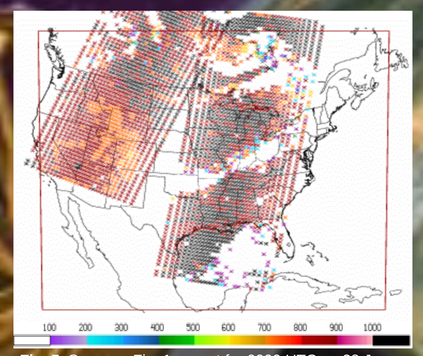

Fig. 5. Same as Fig. 1 except for 0900 UTC on 28 June 2010.

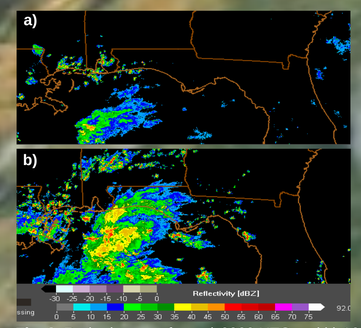

Fig. 6. Radar image s from a) 0900 UTC and b) 1600 UTC on 28 June 2010 showing the origin and spread of thunderstorm activity. Image from National Mosaic & Multi-Sensor QPE.

- Quality AIRS data are located over the Gulf Coast (Fig. 5)
- Radar indicates thunderstorms initiating off the Gulf coast at 0900 UTC (Fig. 6a) and propagating northward throughout the day (Fig. 6b)
- AIRS has higher values of surface based CAPE over the northern Gulf of Mexico when compared to the CNTL (Figs. 7b and 7c)
- RUC and AIRS images are similar with high amounts of CAPE in the Gulf (Figs. 7a and 7c)
- Southerly wind advects unstable air northward consistent with radar
- A vertical sounding from off the southeast Louisiana coast shows that the vertical structure of the AIRS analysis is closer to the RUC than the CNTL over the Gulf, indicating AIRS more accurately represents the vertical structure of the atmosphere than the CNTL (Fig. 8)

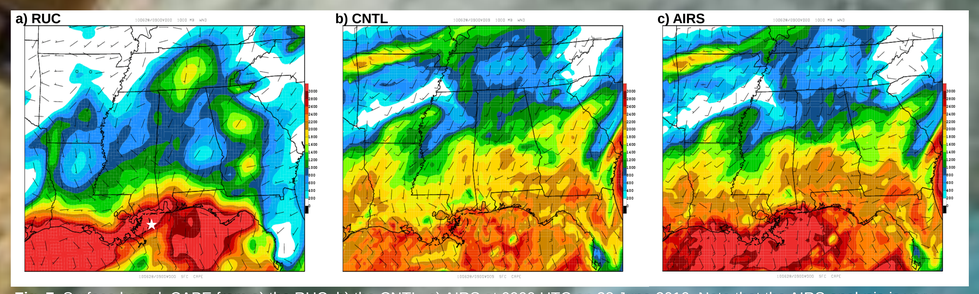

Fig. 7. Surface based CAPE from a) the RUC, b) the CNTL, c) AIRS at 0900 UTC on 28 June 2010. Note that the AIRS analysis is very similar to the RUC. The white star marks the spot where Fig. 8 was taken. Wind is shown for 1000 hPa level.

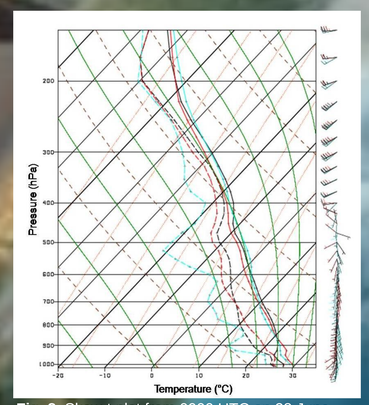

Fig. 8. Skew-t plot from 0900 UTC on 28 June 2010 located at 29.5 N -88.5 W. AIRS more closely represents the vertical structure of the atmosphere than the CNTL run.

Conclusions & Future Work

- An analysis using AIRS profiles produces fields of convective potential closer to an analysis used by an operational forecaster (RUC) than the CNTL analysis over water (data-void regions)
- Mixed results were found when AIRS data were used over land
- Analysis of additional problematic convective forecasts over the Gulf Coast are needed to determine operational impact
- SPoRT plans to transition the AIRS product to select Weather Forecast Office (WFO) partners pending the outcome of these additional tests

References

• Aumann, H. H., M. T. Chahine, C. Gautier, M. D. Goldberg, E. Kalnay, L. M. McMillin, H. Revercomb, P. W. Rosenkranz, 2003: AIRS/AMSU/HSB on the Aqua Mission: Design, Science Objectives, Data Products, and Processing Systems. *IEEE Trans. on Geosci. and Rem. Sens*., **41 (2)**.
• Barker, D. M., W. Haung, Y.-R. Guo, A. J. Bourgeois, and Q. N. Xiao, 2004: A Three-Dimensional Variation Data Assimilation System for MM5: Implementation and Initial Results. *Mon. Wea. Rev*., **132**, 897-914.

Acknowledgements

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